NREL's Field Test Laboratory Building

...making fuels, power, and chemicals

From microorganisms to mounds of trash, researchers at the National Renewable Energy Laboratory's Field Test Laboratory Building (FTLB) are using unseen and unwanted resources to make useful fuels, electricity and chemicals. The FTLB contains the Thermochemical Users Facility and 41 laboratories where a wide range of research activities are conducted to help U.S. industry use renewable resources and waste productively and develop new and more efficient industrial processes. Major laboratory areas are highlighted below.

Thermochemical Users Facility

The state-of-the-art Thermochemical Users Facility (TCUF) is used to convert renewable feedstocks, plastics, waste and other materials into a variety of products, including electricity, high-value chemicals and transportation fuels. The facility can easily be reconfigured to test various types of reactors, filters, catalysts or other unit operations, providing industry users with extensive performance data on their process or equipment. It provides a platform test facility where processes and equipment can be evaluated for potential commercial applications.

The TCUF can accommodate bench-scale reactors that process 0.1 kilogram/hour (0.22 pounds/hour) of feedstock or 20 kg/hr (44 lbs/hr) at the new Thermochemical Process Development Unit (TCPDU). The TCPDU is coupled to state-of-the-art analytical and process control/data acquisition systems to allow real-time monitoring and control of process operations.

For example, using the facility in the fast-pyrolysis mode, sawdust, bark and other biomass material is converted into fuels and chemicals. At high heat fluxes (625°C) in the absence of oxygen, we make a pyrolysis oil rich in phenolic compounds. This oil can be used to make wood adhesives, molded plastics and foam insulation, or it can be burned for electrical generation or converted into gases suitable for production of electricity with fuel cells.

Analytical Laboratories

The Thermochemical Process Development Unit and other FTLB analytical laboratories are used to analyze the chemical composition of products produced from renewable feedstocks. The labs also collect and analyze data to characterize feedstock material and evaluate process control, product quality control, energy use and waste minimization.

Plastics Recycling Laboratory

Researchers study ways to recycle plastics and recover high-value chemicals using an innovative technology known as selective pyrolysis and combinations of pyrolysis and other thermal and catalytic treatments. The technology is particularly adaptable to recycling old carpets into building blocks for new carpets.

Selective pyrolysis is conducted in small, fluidized bed reactors that melt carpet made of nylon 6 fiber (a plastic used to make 30 percent of carpeting) and converts the plastic material into caprolactam, the chemical used to make the nylon 6 fiber. Recycled caprolactam can be made at half the cost of new caprolactam and uses only a third as much energy.

Other mixtures of plastics can be converted into useful chemicals. An example is waste from phenol-formaldehyde thermosetting resins (bakelite) into phenolic replacements for new phenol.

Microalgal Biotechnology Labs

Research conducted in these labs is aimed at producing biodiesel fuel from microalgae and other plants. Biodiesel fuel is made from oils and fats found in microalgae. It can be substituted for diesel fuel or used as an additive. Biodiesel generates fewer pollutants than typical diesel fuels.

Typically, microalgae are grown in ponds, harvested and the oils extracted. The extracted oils are chemically reacted with alcohols to produce diesel fuels. Research in the laboratory is directed towards genetic enhancement of the fat and oil content of the algae to make the biodiesel fuel product more cost-competitive by 2010.

Biomass Conversion/Organic Synthesis Labs

NREL has undertaken two major efforts in these laboratories. First, new methods to separate the basic components of biomass (cellulose, lignin, hemicellulose and extractives) are being examined for cost-effectiveness and yield. The products resulting from these processes would be useful for commercial fiber productions uch as paper, packaging materials and fabric (such as rayon).

Second, NREL is investigating processes that convert bio-based materials into potentially useful chemicals and materials. For example, wood adhesives or resins used to manufacture some kinds of plastics are typically made from phenol and formaldehyde derived from petroleum feedstocks. NREL researchers are looking at using processed pyrolysis oils as a suitable replacement for phenol—at half the cost. With the U.S. now using more than one billion pounds of phenol annually, the potential cost savings are enormous. Another example would be the conversion of processed wood wastes—such as pulping sludge into fuel additives or agrichemicals.

Photobiology Laboratories

In these labs, NREL researchers are looking at microbes to clean up the environment and make hydrogen and biodegradable plastics. Microbes integrated with electrodes also serve as biosensors to detect explosives, drugs and organic pollutants. Other examples include:

Binding Leachable Metals—Slime secreted by algae is embedded in special bioreactors and used to bind metals. As contaminated water flows through the reactor, the slime layer traps and binds metal ions, leaving only contaminant-free water.

Photosynthetic Bacteria—Researchers use bacteria to clean up soil and water tainted with contaminants from pesticides, wood preservatives and polychlorinated biphenyls (PCBs) used in electrical insulators. Fueled by sunlight, the bacteria breaks down the contaminants.

Biodegradable Plastics—NREL-developed biodegradable plastics are consumed in weeks by soil-bound microbes. The potential market for biodegradable plastics is several billion pounds per year. Several large corporations are considering commercializing the technology.

Hydrogen Production—Algae are used to separate hydrogen from water to produce clean-burning hydrogen to power vehicles and power plants. Because algae are not inherently proficient at this process, researchers genetically engineer algae to more readily produce hydrogen.

Analysis and Process Control with a Molecular Beam Mass Spectrometer

The NREL-developed Molecular Beam Mass Spectrometry (MBMS) system directly extracts and analyzes gases and vapors produced in high-temperature or reactive systems. Data from the MBMS helps researchers determine the effectiveness of processes such as solar and thermal destruction of toxic gases and selective pyrolysis of mixed plastics to recover valuable chemicals. NREL has also developed a transportable MBMS system designed to perform field monitoring of effluents, gases and other emissions produced from biomass power systems. The use of this system for process control is being evaluated in the TCUF.

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